

For Revised Syllabus Session 2024-25

EXEMPLAR SOLUTIONS

PHYSICS

Chapter 4 :-Moving Charges and Magnetism

Class 12

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Chapter 4-
Moving Charges and Magnetism

Multiple Choice Questions I

4.1. Two charged particles traverse identical helical paths in a completely opposite sense in a uniform magnetic field $B = B_0\hat{k}$

a) they have equal z-components of momenta
b) they must have equal charges
c) they necessarily represent a particle-antiparticle pair
d) the charge to mass ratio satisfy: (e/m)1 + (e/m)2 = 0
Answer:
d) the charge to mass ratio satisfy: (e/m)1 + (e/m)2 = 0

4.2. Biot-Savart law indicates that the moving electrons produce a magnetic field B such that
a) B ⊥ v
b) B ∥ v
c) it obeys inverse cube law
d) it is along the line joining the electrons and point of observation
Answer:
a) B ⊥ v

4.3. A current circular loop of radius R is placed in the x-y plane with centre at the origin. Half of the lop with x > 0 is now bent so that it now lies in the y-z plane.
a) the magnitude of magnetic moment now diminishes
b) the magnetic moment does not change
c) the magnitude of B at (0,0,z),z >> R increases
d) the magnitude of B at (0,0,z),z >> R is unchanged
Answer:
a) the magnitude of magnetic moment now diminishes

4.4. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?
a) the electron will be accelerated along the axis
b) the electron path will be circular about the axis
c) the electron will experience a force at 45º to the axis and hence execute a helical path
d) the electron will continue to move with uniform velocity along the axis of the solenoid
Answer:
d) the electron will continue to move with uniform velocity along the axis of the solenoid

4.5. In a cyclotron, a charged particle
a) undergoes acceleration all the time
b) speeds up between the dees because of the magnetic field
c) speeds up in a dee
d) slows down within a dee and speeds up between dees
Answer:
c) speeds up in a dee

4.6. A circular current loop of magnetic moment M is in an arbitrary orientation in an external magnetic field B. The work done to rotate the loop by 30o about an axis perpendicular to its plane is
a) MB

b) √3 MB/2
c) MB/2
d) zero
Answer:
d) zero

Multiple Choice Questions II

4.7. The gyro-magnetic ratio of an electron in an H-atom, according to Bohr model is
a) independent of which orbit it is in
b) negative
c) positive
d) increases with the quantum number n
Answer:
a) independent of which orbit it is in
b) negative

4.8. Consider a wire carrying a steady current, I placed un a uniform magnetic field B perpendicular to its length. Consider the charges inside the wire. It is known that magnetic forces do not work. This implies that
a) motion of charges inside the conductor is unaffected by B since they do not absorb energy
b) some charges inside the wire move to the surface as a result of B
c) if the wire moves under the influence of B, no work is done by the force
d) if the wire moves under the influence of B, no work is done by the magnetic force on the ions, assumed fixed within the wire
Answer:
b) some charges inside the wire move to the surface as a result of B
d) if the wire moves under the influence of B, no work is done by the magnetic force on the ions, assumed fixed within the wire

4.9. Two identical current carrying coaxial loops, carry current I in an opposite sense. A simple amperian loop passes through both of them once. Calling the loop as C,
a)

$$\oint_c B.dl = \mp 2\mu_0 I$$

b) the value of $\oint_c B.dl$ is independent of sense of C
c) there may be a point on C where B and dl are perpendicular
d) B vanishes everywhere on C
Answer:

b) the value of $\oint_c B.dl$ is independent of sense of C

c) there may be a point on C where B and dl are perpendicular

4.10. A cubical region of space is filled with some uniform electric and magnetic fields. An electron enters the cube across one of its faces with velocity v and a positron enters via opposite face with velocity –v. At this instant,
a) the electric forces on both the particles cause identical acceleration
b) the magnetic forces on both the particles cause equal accelerations
c) both particles gain or lose energy at the same rate
d) the motion of the centre of mass (CM) is determined by B alone
Answer:
b) the magnetic forces on both the particles cause equal accelerations
c) both particles gain or lose energy at the same rate
d) the motion of the centre of mass (CM) is determined by B alone

4.11. A charged particle would continue to move with a constant velocity in a region wherein,
a) $E = 0, B \neq 0$
b) $E \neq 0, B \neq 0$
c) $E \neq 0, B = 0$
d) $E = 0, B = 0$
Answer:
a) $E = 0, B \neq 0$
b) $E \neq 0, B \neq 0$
d) $E = 0, B = 0$

Very Short Answers

4.12. Verify that the cyclotron frequency $\omega = eB/m$ has the correct dimensions of $[T]^{-1}$.
Answer:
The path traced by the particle in a cyclotron is a circular path in which magnetic force acts as a centripetal force
$mv^2/R = evB$
$eB/m = v/R = \omega$
$B = F/ev = [MLT^{-2}]/[AT][LT^{-1}] = [MA^{-1}T^{-2}]$
$[\omega] = [eB/m] = [v/R] = [T]^{-1}$

4.13. Show that a force that does no work must be a velocity dependent force.
Answer:

$$dW = \underset{F}{\rightarrow} \cdot \underset{dl}{\rightarrow} = 0$$

$$\underset{F}{\rightarrow} \cdot \underset{v}{\rightarrow} dt = 0$$

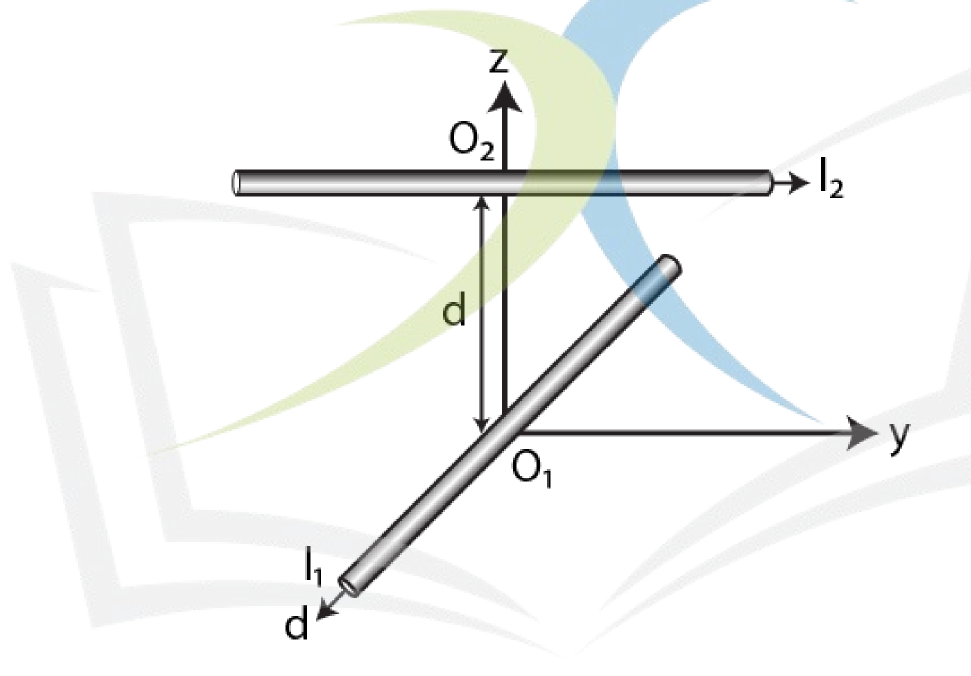
$$\underset{F}{\rightarrow} \cdot \underset{v}{\rightarrow} = 0$$

4.14. The magnetic force depends on v which depends on the inertial frame of reference. Does then the magnetic force differ from inertial frame to frame? Is it reasonable that the net acceleration has a different value in different frames of reference?

Answer:
The net acceleration can have a different value in different frames of reference as velocity depends on frame of reference.

4.15. Describe the motion of a charged particle in a cyclotron if the frequency of the radio frequency (rf) field were doubled.
Answer:
When the frequency of the radio frequency field were doubled, the time period of the radio frequency is halved which results in half revolution of the charges.

4.16. Two long wires carrying current I1 and I2 are arranged as shown in the figure. The one carrying I1 is along is the x-axis. The other carrying current I2 is along a line parallel to the y-axis given by x = 0 and z = d. Find the force exerted at O2 because of the wire along the x-axis.



Answer:
The magnetic field B on a current carrying conductor is given as $F = I(L \times B) = ILB \sin\theta$
O_2 and I_1 are parallel to the y-axis and are in the direction of –Y
I_2 is parallel to the y-axis and is along Y-axis therefore, the angle between I_2 and B_1 is zero. The magnetic force F_2 is given as $F_2 = B_1I_2L_1 \sin 0^o = 0$
Therefore, the force on O_2 has current I_1 zero.

Short Answers

4.17. A current carrying loop consists of 3 identical quarter circles of radius R, lying in the positive quadrants of the x-y, y-z, and z-x planes with their centres at the origin, joined together. Find the direction and magnitude of B at the origin.
Answer:
The vector sum of the magnetic field at the origin due to the quarter is given as

$$\vec{B}_{net} = \frac{1}{4}\left(\frac{\mu_0 I}{2R}\right)(\hat{i} + \hat{j} + \hat{k})$$

4.18. A charges particle of charge e and mass m is moving in an electric field E and magnetic field B. Construct dimensionless quantities and quantities of dimension $[T]^{-1}$.

Answer:

$mv^2/R = evB$

$eB/m = v/R = \omega$

$B = F/ev = [MA^{-1}T^{-2}]$

$[\omega] = [eB/m]=[v/R] = [T^{-1}]$

4.19. An electron enters with a velocity v = v0i into a cubical region in which there are uniform electric and magnetic fields. The orbit of the electron is found to spiral down inside the cube in plane parallel to the x-y plane. Suggest a configuration of fields E and B that can lead to it.

Answer:

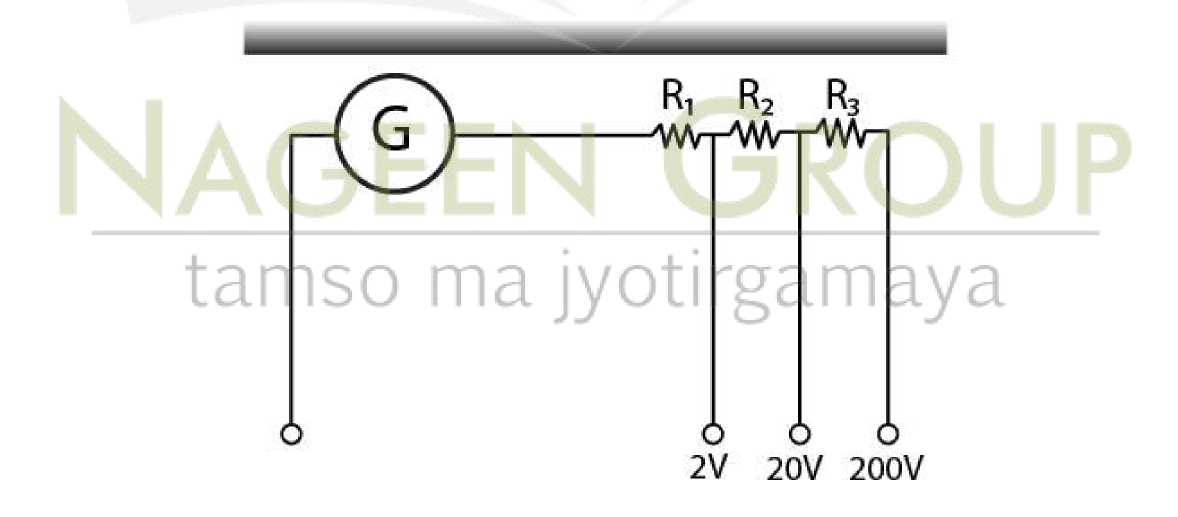
The configuration of the fields E and B are spiral path.

4.20. Do magnetic forces obey Newton's third law. Verify for two current elements $dl_1 = dl\hat{i}$ located at the origin and $dl_2 = dl\hat{j}$ located at (0,R,0). Both carry current I.

Answer:

The magnetic forces do not obey Newton's third law if there is no current flowing in the conductor which is placed parallel to each other.

4.21. A multirange voltmeter can be constructed by using a galvanometer circuit as shown in the figure. We want to construct a voltmeter that can measure 2V, 20V, and 200V using galvanometer of resistance 10Ω and that produces maximum deflection for current of 1 mA. Find R1, R2, and R3 that have to be used.



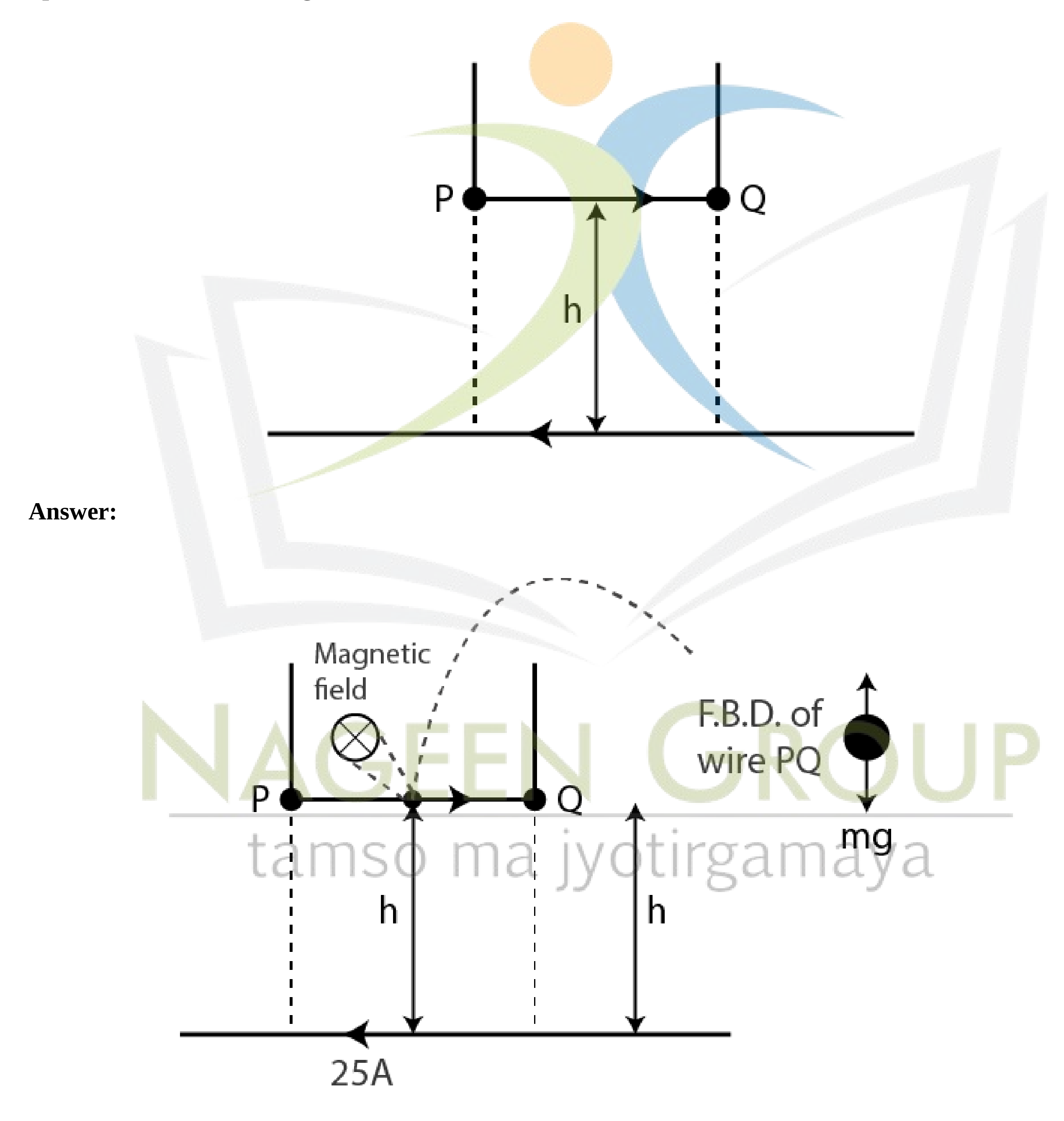
Answer:

$i_G(G+R1) = 2$ for 2V range

$i_G(G+R1+R2) = 20$ for 20V range

$i_G(G+R1+R2+R3) = 200$ for 200V range
Solving the above, we get
R1 = 1990 Ω
R2 = 18kΩ
R3 = 180 kΩ

4.22. A long straight wire carrying current of 25 A rests on a table as shown in the figure. Another wire PQ of length 1 m, mass 2.5 g carries the same current but in the opposite direction. The wire PQ is free to slide up and down. To what height will PQ rise?



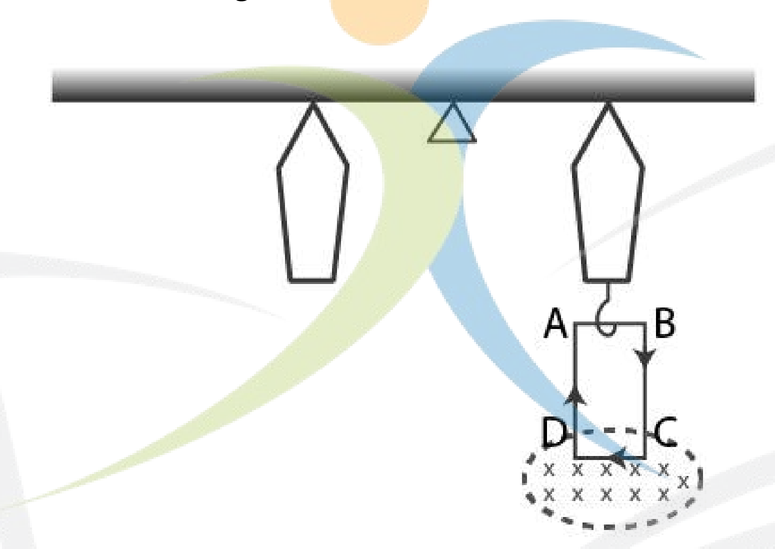
Answer:

The magnetic field produced by a long straight current carrying wire is given as

$B = \mu_0 I/2\pi h$
Magnetic force on the small conductor is $F = BIl \sin\theta = BIl$
$F = mg = \mu_0 I^2 l/2\pi h$
$h = 0.51$ cm

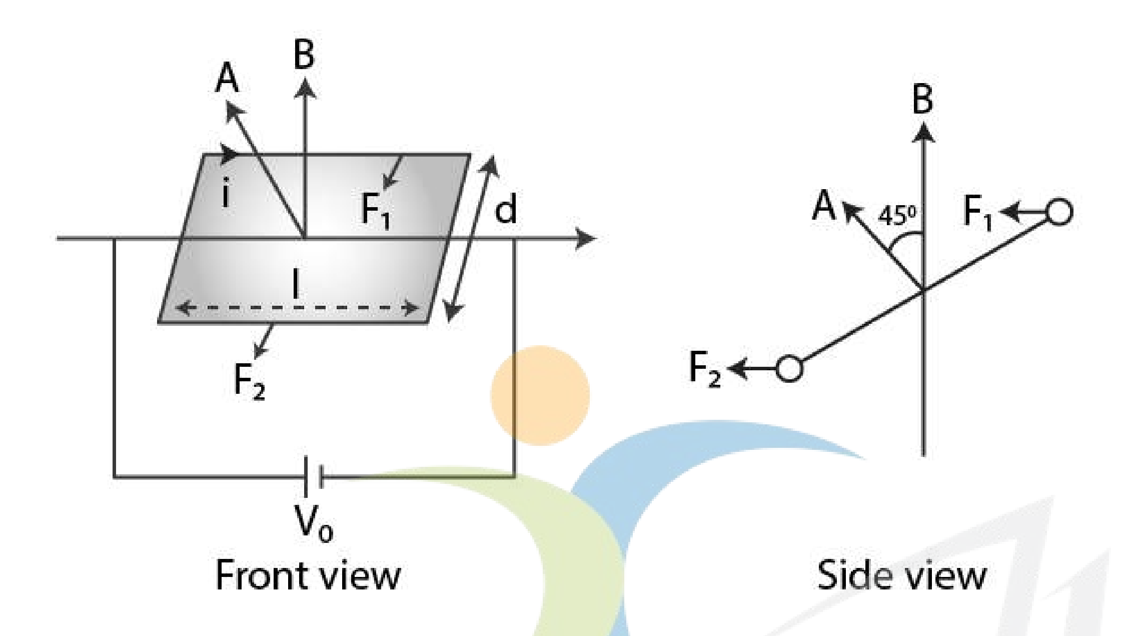
Long Answers

4.23. A 100 turn rectangular coil ABCD is hung from one arm of a balance. A mass 500 g is added to the other arm to balance the weight of the coil. A current 4.9 A passes through the coil and a constant magnetic field of 0.2 T acting inward is switched on such that only arm CD of length 1 cm lies in the field. How much additional mass 'm' must be added to regain the balance?



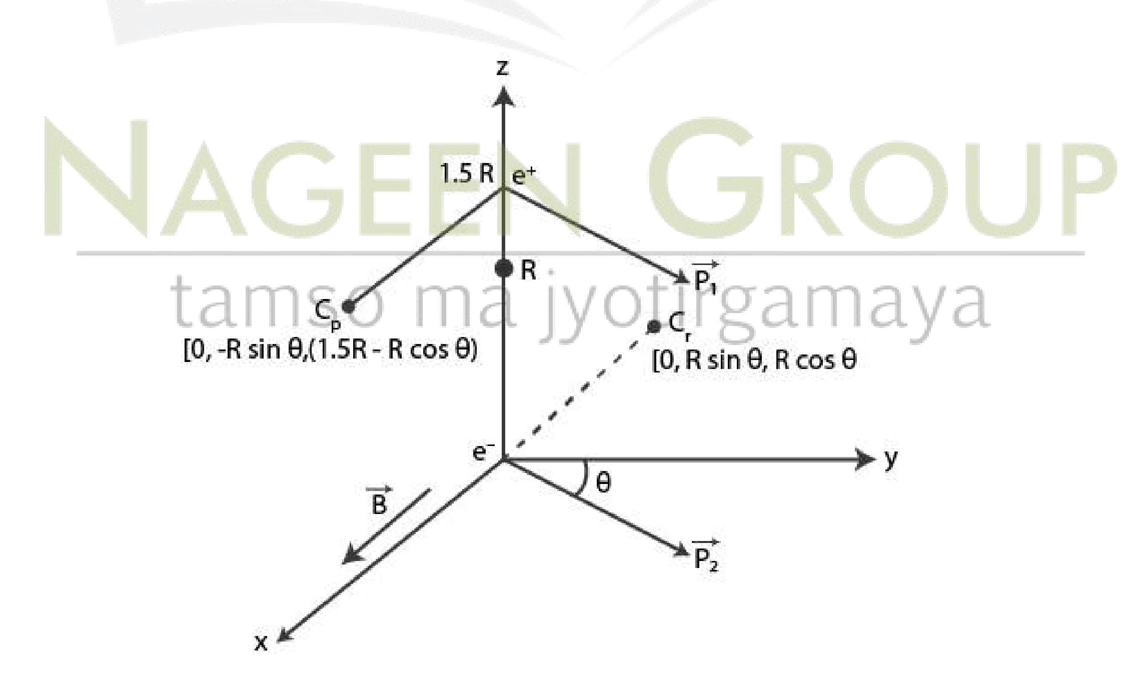
Answer:
When t = 0, the external magnetic field is off.
$Mgl = W_{coil}\ l$
$0.5\ gl = W_{coil}\ l$
Wcoil = 0.5 9.8 N
Let m be the mass which is added to regain the balance
When the magnetic field is switched is on,
Mgl + mgl = (ILC)l
m = 1 g

4.24. A rectangular conducting loop consists of two wires on two opposite sides of length l joined together by rods of length d. The wires are each of the same material but with cross-sections differing by a factor of 2. The thicker wire has a resistance R and the rods are of low resistance, which in turn are connected to a constant voltage source Vo. The loop is placed in uniform a magnetic field B at 45oto its plane. Find τ, the torque exerted by the magnetic field on the loop about an axis through the centres of rods.
Answer:



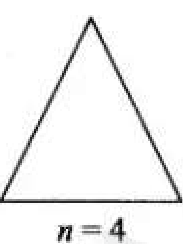
Force and torque on the first wire is given as
$F_1 = i_1 l\ B \sin 90^o = V_0/2R\ lB$
$\tau_1 = d/2\sqrt{2}$
$F_1 = V_0 ldB/2\sqrt{2}\ R$
$\tau = 1/4\sqrt{2}\ V_0 AB/R$

4.25. An electron and a positron are released from (0, 0, 0) and (0, 0, 1.5R) respectively, in a uniform magnetic field $B = B_0\hat{i}$ **each with an equal momentum of magnitude p = eBR. Under what conditions on the direction of momentum will the orbits be non-intersecting circles?**
Answer:

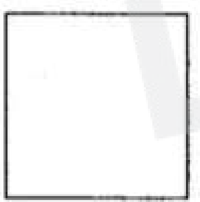


When the centres are greater than 2R, then the circular orbits of electron and positron shall not overlap.
Let d be the distance between Cp and Ce
Then $d^2 = 4R^2 + 9/4R^2 – 6R^2 \cos\theta$
As d is greater than 2R,
$9/4 > 6 \cos \theta$ or $\cos \theta < 3/8$

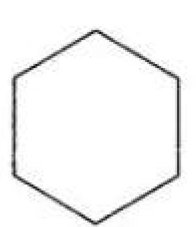
4.26. A uniform conducting wire of length 12a and resistance R is wound up as a current carrying coil in the shape of i) an equilateral triangle of side a; ii) a square if sides a and iii) a regular hexagon of sides a. The coil is connected to a voltage source V0. Find the magnetic moment of the coils in each case.
Answer:
a) An equilateral triangle with side a
No.of loops = 4
Area of the triangle $A = \sqrt{3}/4\ a^2$
Magnetic moment, $m = Ia2\sqrt{3}$



b) For a square with sides a
Area, $A = a^2$
No.of loops = 3
Magnetic moment, $m = 3Ia^2$



c) For a regular hexagon with sides a
Area, $A = 6\sqrt{3}/4\ a^2$
No.of loops = 2
Magnetic moment, $m = 3\sqrt{3}a^2I$



4.27. Consider a circular current-carrying loop of radius R in the x-y plane with centre at origin. Consider the line integral $\Im(L) = \left| \int_{-L}^{L} B.dl \right|$ **taken along z-axis.**

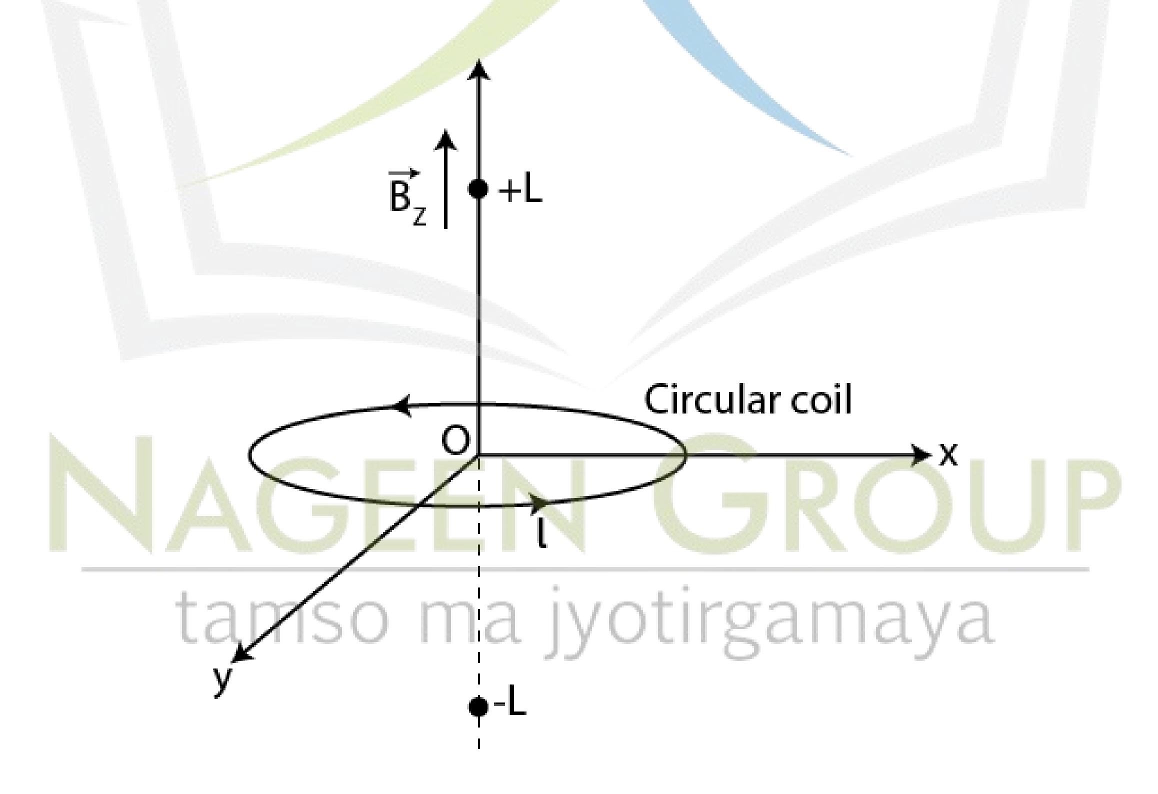
a) show that $\Im(L)$ **monotonically increases with L**

b) use an appropriate Amperian loop to that $\Im(\infty) = \mu_0 I$ **where I is the current in the wire**

c) verify directly the above result

d) suppose we replace the circular coil by a square coil of sides R carrying the same current I. What can you say about $\Im(\infty)$ *and* $\Im(L)$

Answer:



a) Magnetic field due to a circular current-carrying loop is given as

$$\Im(L) = \int_{-L}^{+L} Bdl = 2BL$$

It is a monotonically increasing function of L

b) The Amperian loop is given as

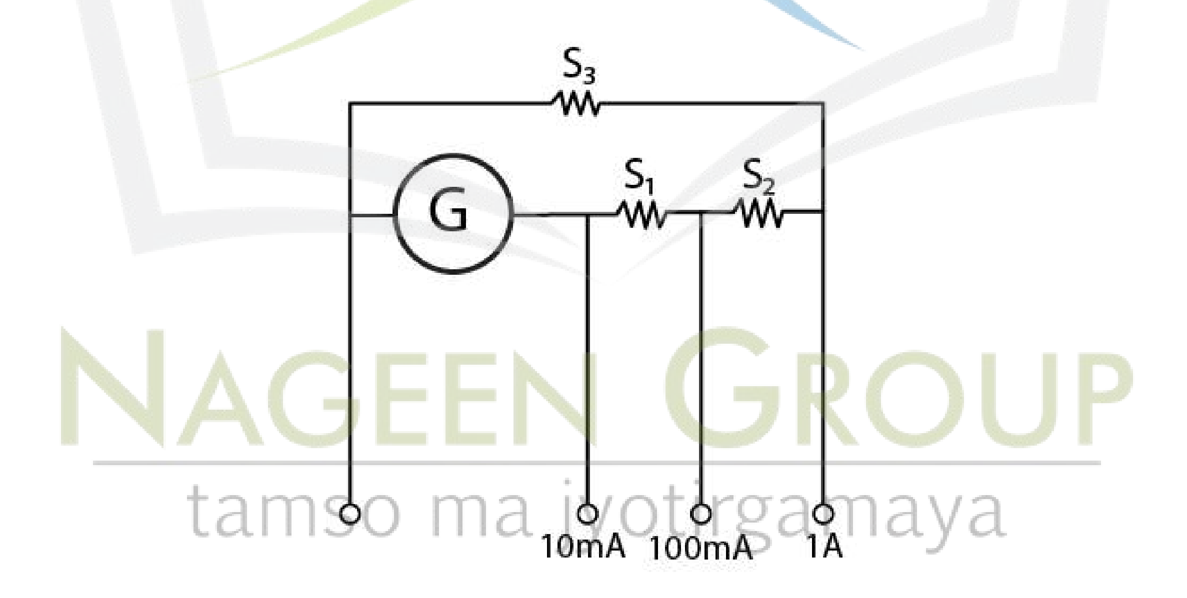
$$\Im(\infty) = \oint_{-\infty}^{+\infty} \underset{B}{\rightarrow} \cdot \underset{dl}{\rightarrow} = \mu_0 I$$

c) The magnetic field at the axis of the circular coil is given as μ0I

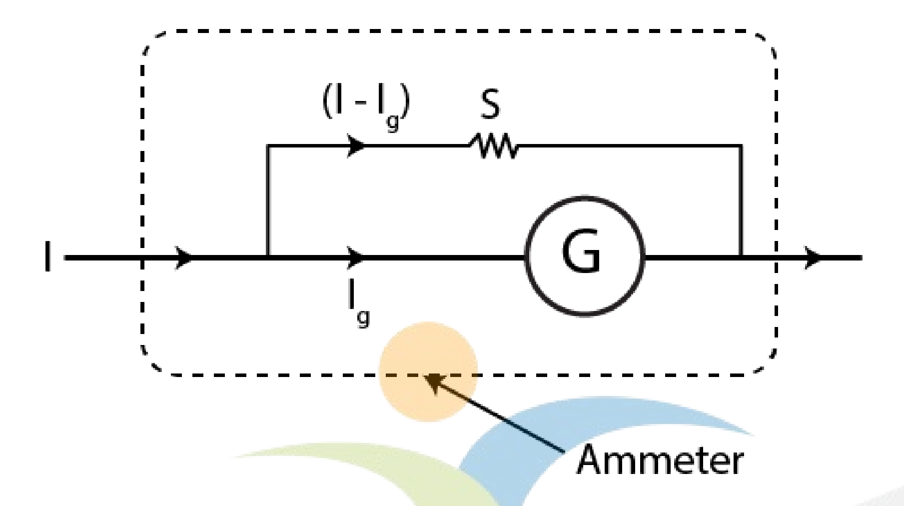
d) When a circular coil is replaced with a square coil, it is given as

$$\Im(\infty)_{square} = \Im(\infty)_{circular\ coil}$$

4.28. A multirange current meter can be constructed by using a galvanometer circuit shown in the figure. We want a current meter that can measure 10 mA, 100 mA, and 1 A using a galvanometer of resistance 10Ω and that produces maximum deflection for current of 1 mA. Find S1, S2, and S3 that have to be used.

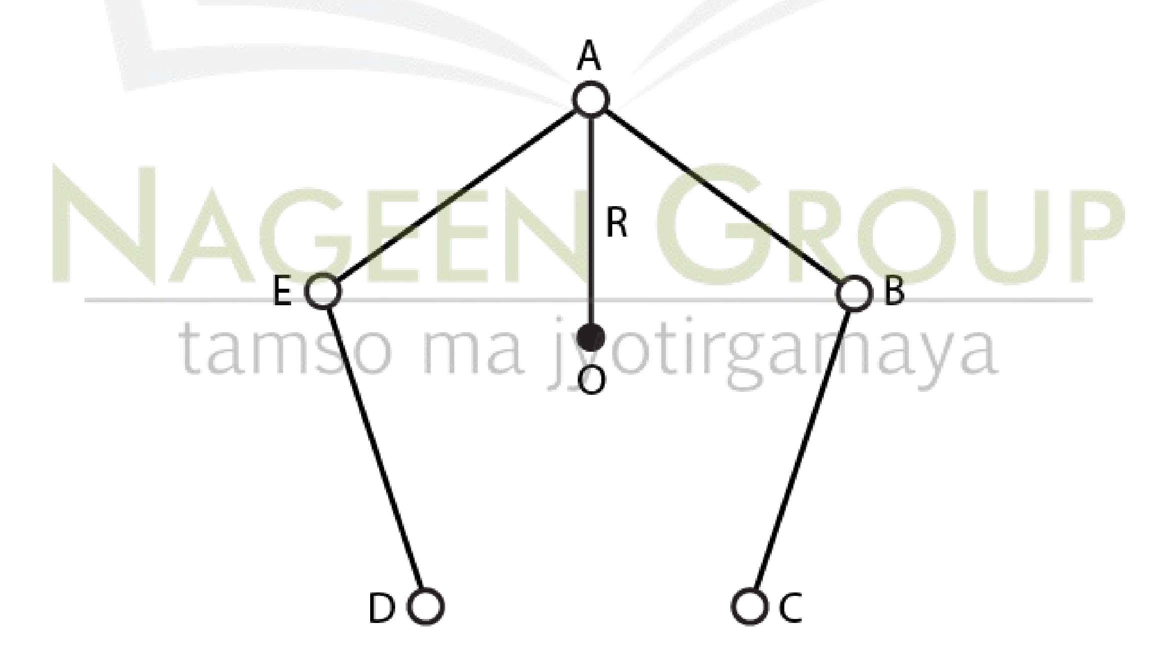


Answer:



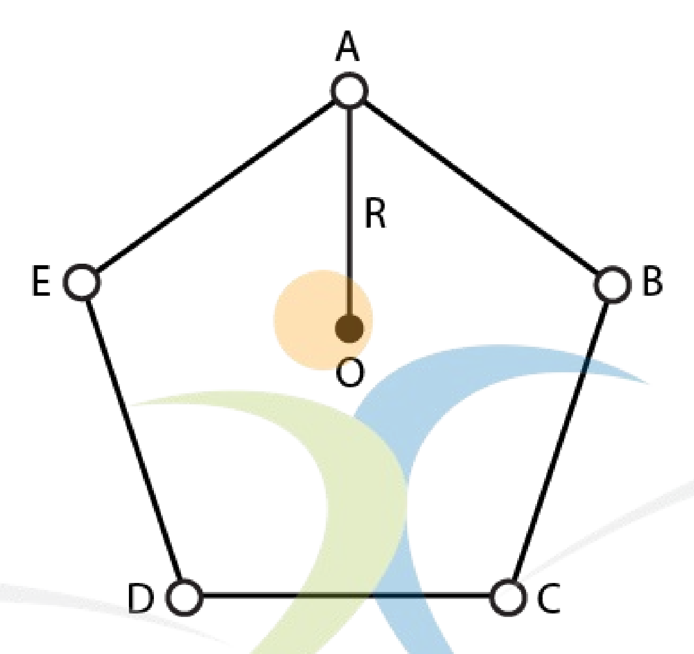
I_1 is measured as = 10 mA = $I_G G = (I_1 – I_G)(S_1 + S_2 + S_3)$
I_2 is measured as = 100 mA = $I_G(G+S_1)=(I_2-I_G)(S_2-S_3)$
I_3 is measured as = 1 A = $I_G(G+S_1+S_2)=(I_3-I_G)(S_3)$
$S_1 = 1\ \Omega$
$S_2 = 0.1\ \Omega$
$S_3 = 0.01\ \Omega$

4.29. Five long wires A, B, C, D, and E each carrying I are arranged to form edges of a pentagonal prism as shown in the figure. Each carries current out of the plane of paper.
a) what will be magnetic induction at a point on the axis O> Axis is at a distance R from each wire
b) what will be the field if current in one of the wires is switched off
c) what if current in one of the wire A is reversed



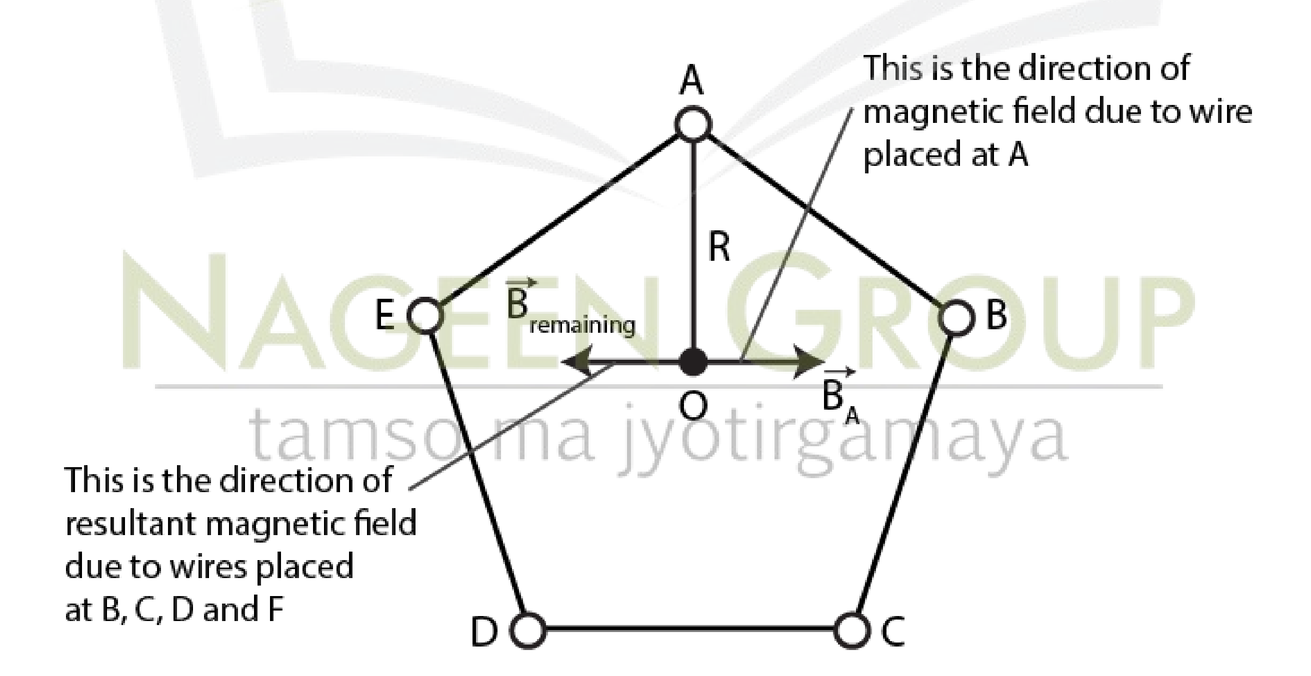
Answer:

a)



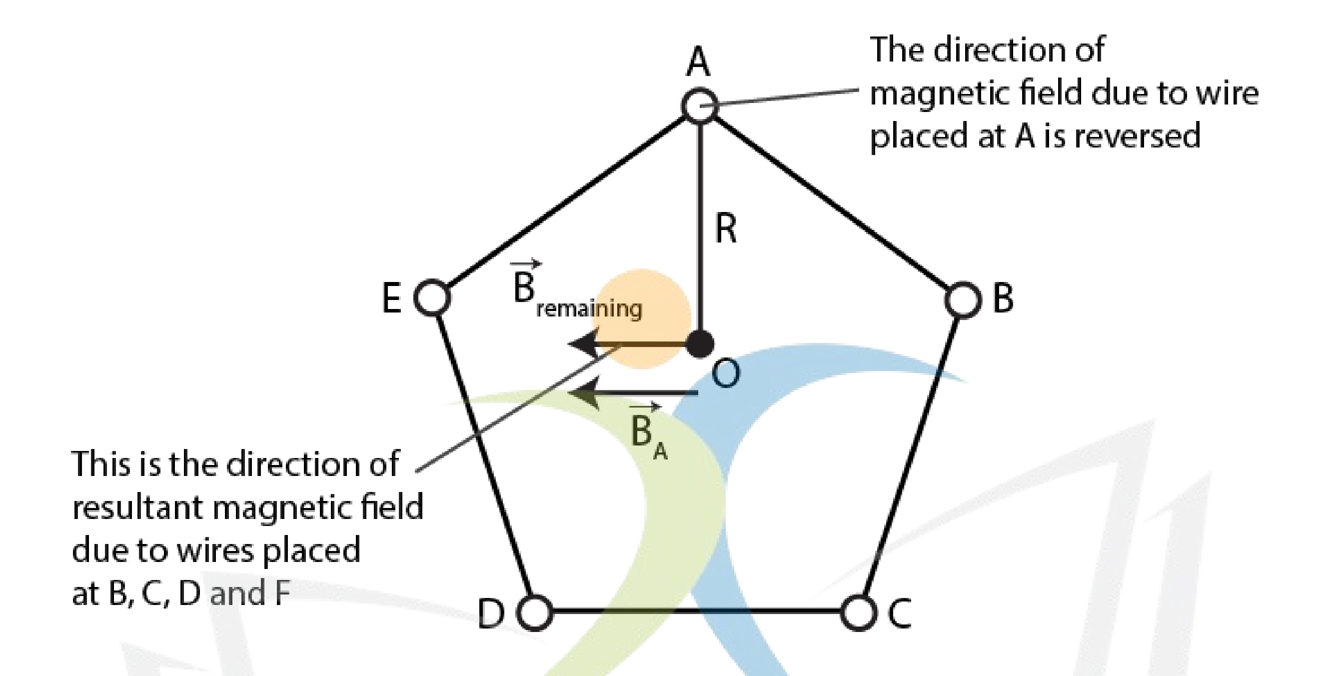
The magnetic induction at a point on the axis will be 0 which is represented by R as A, B, C, D, and E are perpendicular to the plane of paper at the given locations.

b)



When the current in one of the wires is switched off, the field $\mu_0/2\pi$ i/R will be perpendicular to AO towards left.

c)



If the current is reversed, then the total magnetic field induction at O is $\mu_0/4\pi R$ 2I/R

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CLASS 12: PHYSICS (ALL CHAPTERS)




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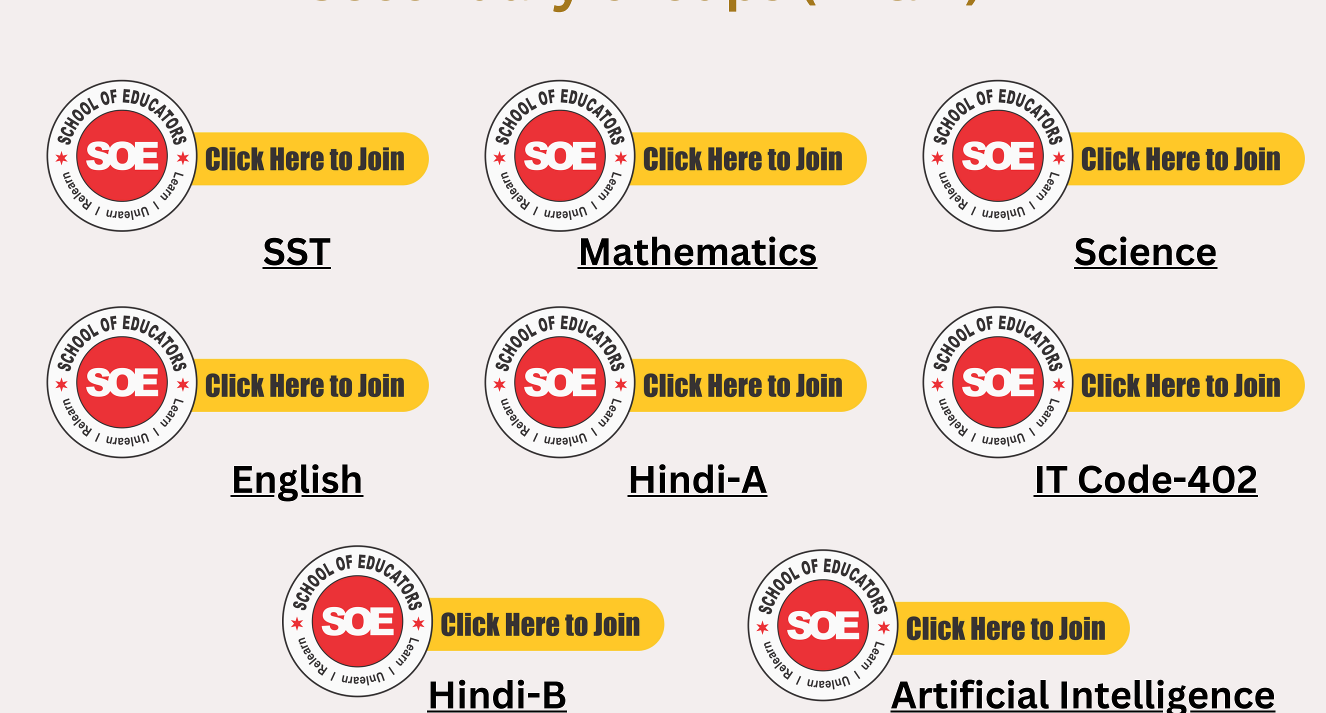
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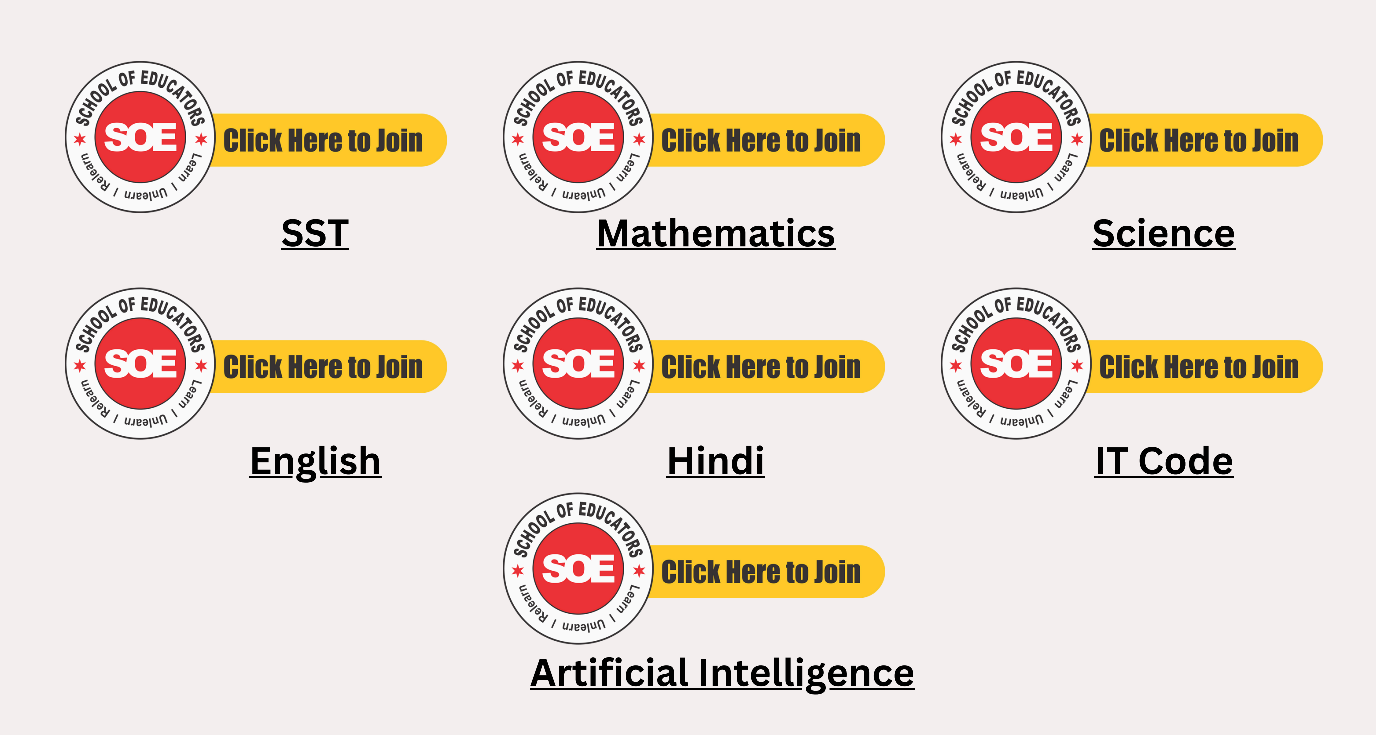


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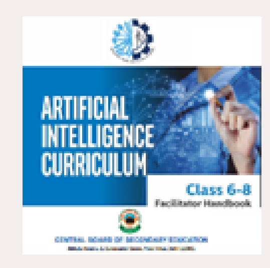
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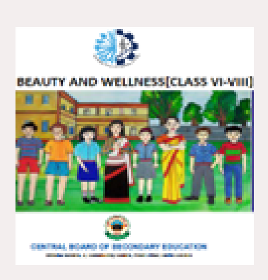
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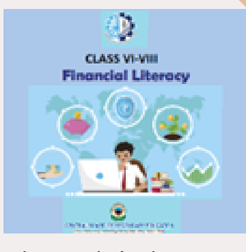
Artificial Intelligence



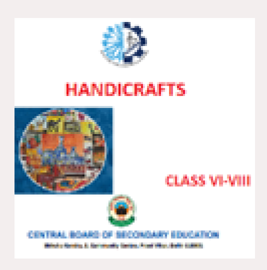
Beauty & Wellness



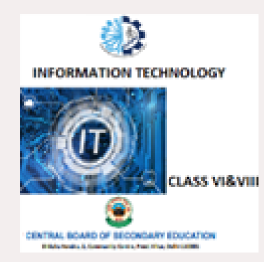
Design Thinking & Innovation



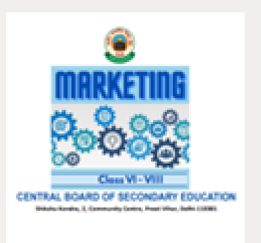
Financial Literacy



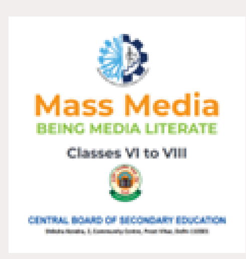
Handicrafts



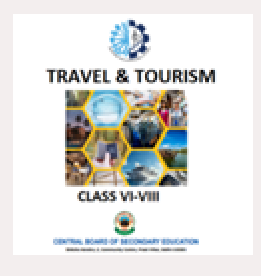
Information Technology



Marketing/Commercial Application



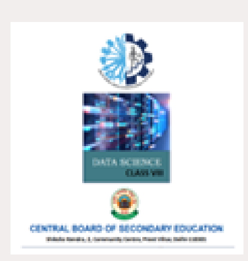
Mass Media - Being Media Literate



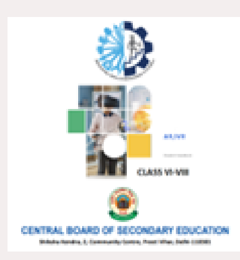
Travel & Tourism



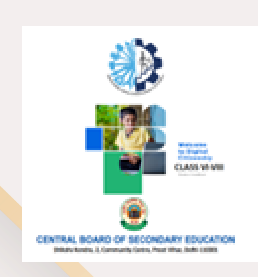
Coding



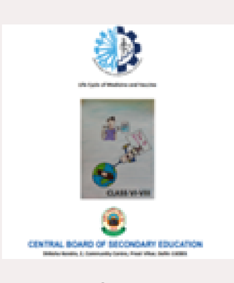
Data Science (Class VIII only)



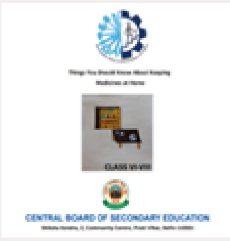
Augmented Reality / Virtual Reality



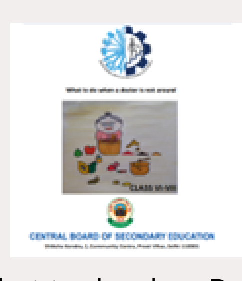
Digital Citizenship



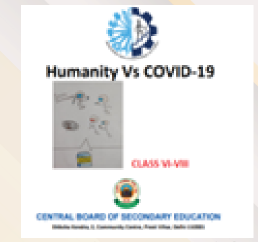
Life Cycle of Medicine & Vaccine



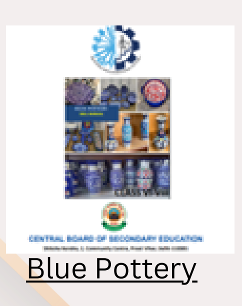
Things you should know about keeping Medicines at home



What to do when Doctor is not around

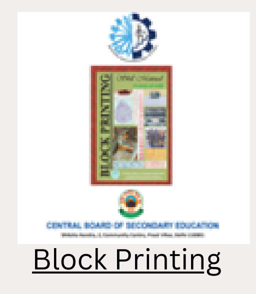


Humanity & Covid-19

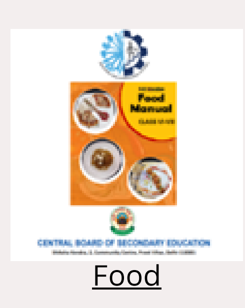


Blue Pottery

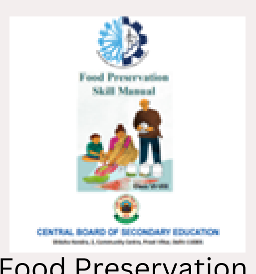
Pottery



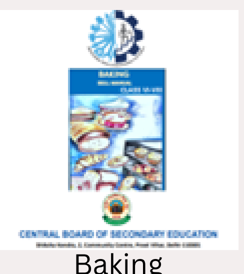
Block Printing



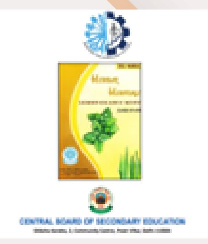
[Food](#)

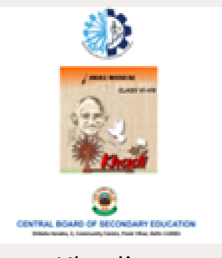


[Food Preservation](#)

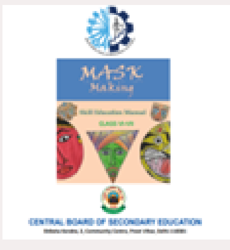


[Baking](#)

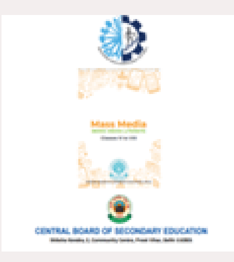

[Herbal Heritage](#)



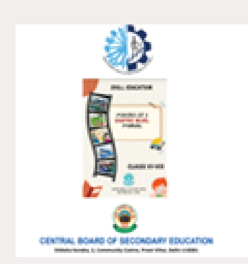
[Khadi](#)



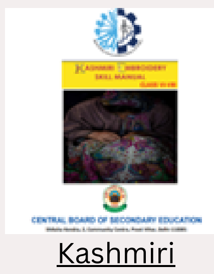
[Mask Making](#)



[Mass Media](#)



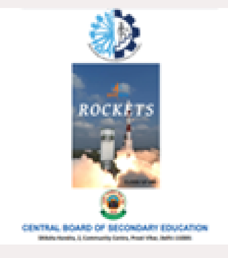
[Making of a Graphic Novel](#)



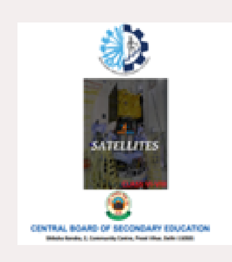
[Kashmiri Embroidery](#)



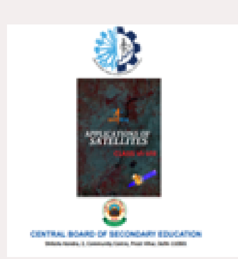
[Embroidery](#)



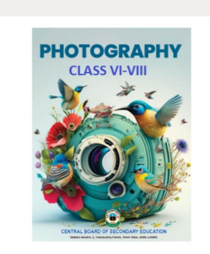
[Rockets](#)



[Satellites](#)



[Application of Satellites](#)

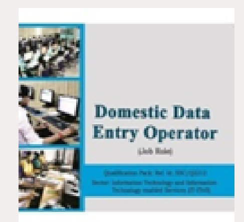


[Photography](#)

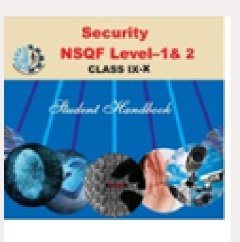
SKILL SUBJECTS AT SECONDARY LEVEL (CLASSES IX – X)



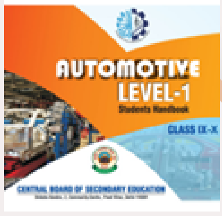
Retail



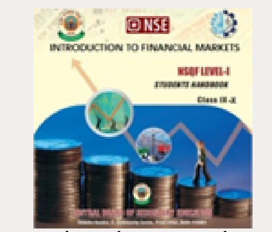
Information Technology



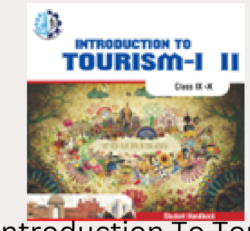
Security



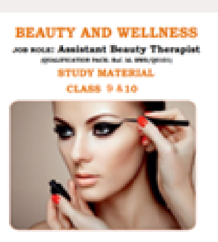
Automotive



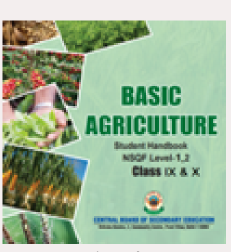
Introduction To Financial Markets



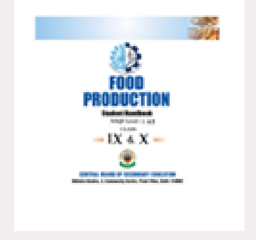
Introduction To Tourism



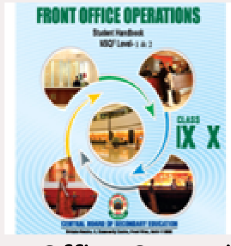
Beauty & Wellness



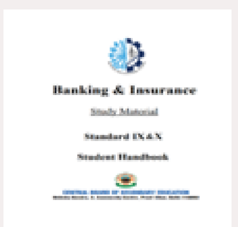
Agriculture



Food Production



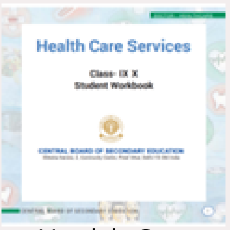
Front Office Operations



Banking & Insurance



Marketing & Sales



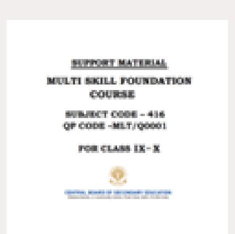
Health Care



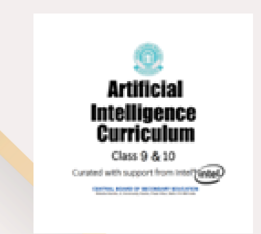
Apparel



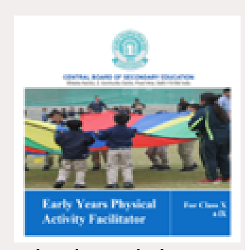
Multi Media



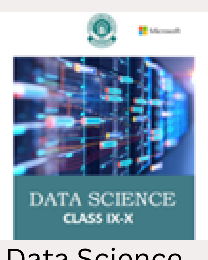
Multi Skill Foundation Course



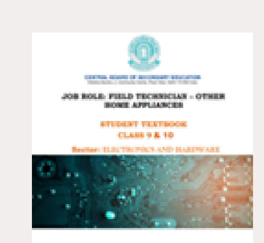
Artificial Intelligence



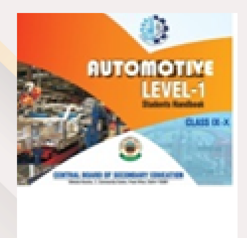
Physical Activity Trainer



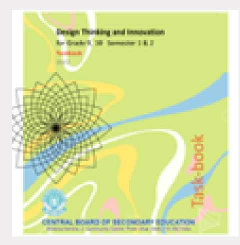
Data Science



Electronics & Hardware (NEW)

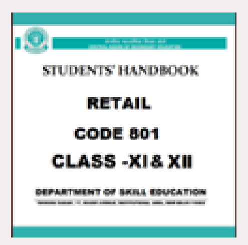


Foundation Skills For Sciences (Pharmaceutical & Biotechnology)(NEW)

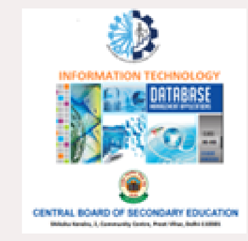


Design Thinking & Innovation (NEW)

SKILL SUBJECTS AT SR. SEC. LEVEL (CLASSES XI – XII)



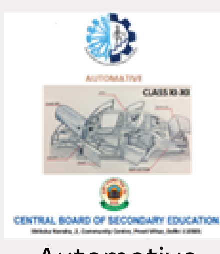
Retail



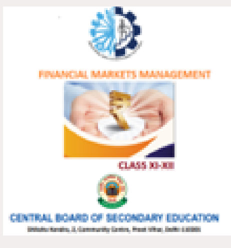
InformationTechnology



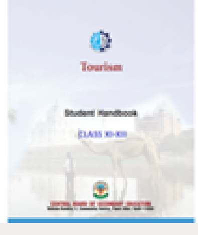
Web Application



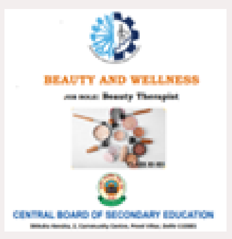
Automotive



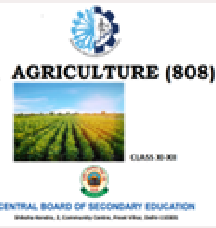
Financial Markets Management



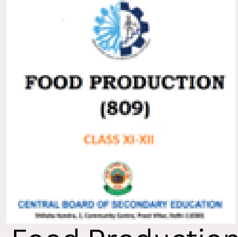
Tourism



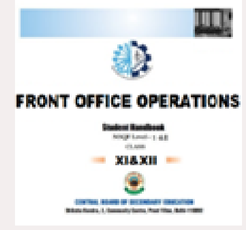
Beauty & Wellness



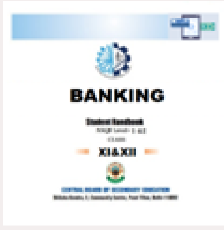
Agriculture



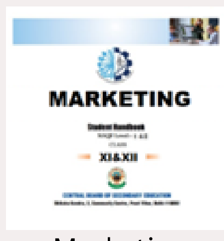
Food Production



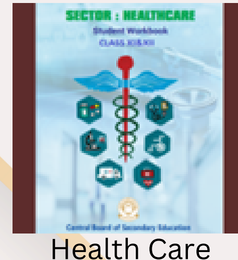
Front Office Operations



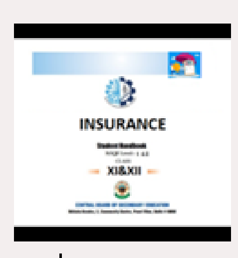
Banking



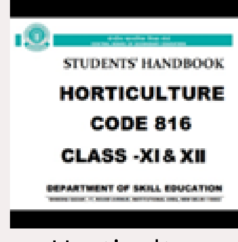
Marketing



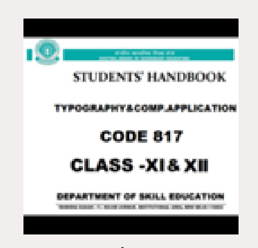
Health Care



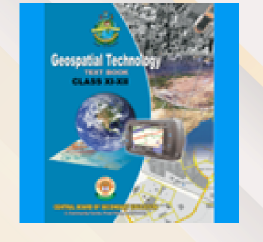
Insurance



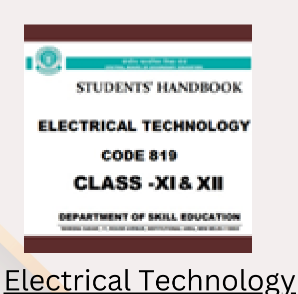
Horticulture



Typography & Comp. Application

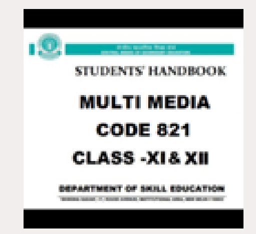


Geospatial Technology

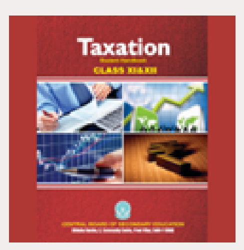


Electrical Technology

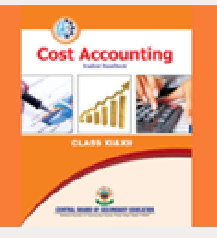
Electronic Technology



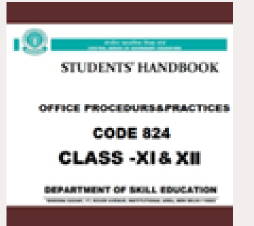
Multi-Media



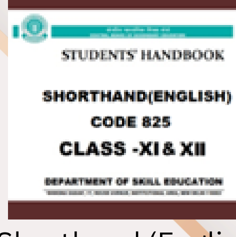
Taxation



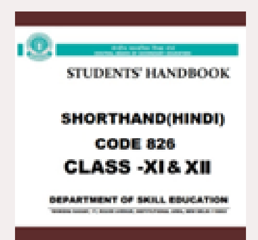
Cost Accounting



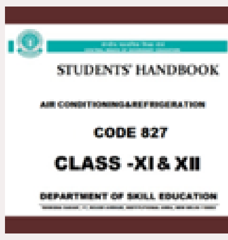
Office Procedures & Practices



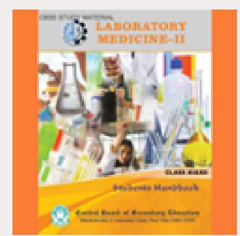
Shorthand (English)



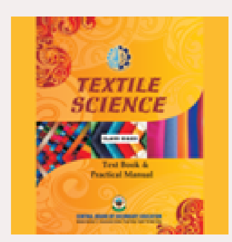
Shorthand (Hindi)



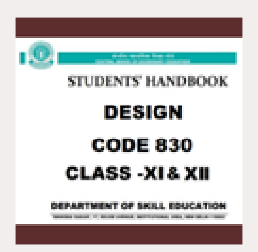
Air-Conditioning & Refrigeration



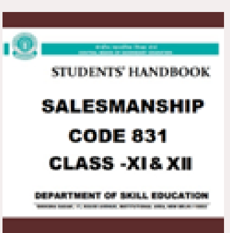
Medical Diagnostics



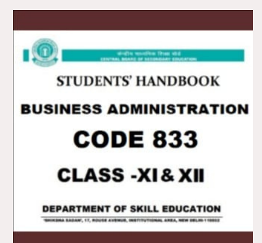
Textile Design



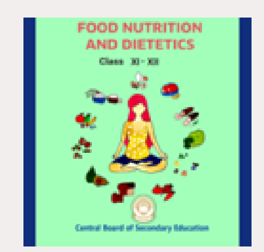
Design



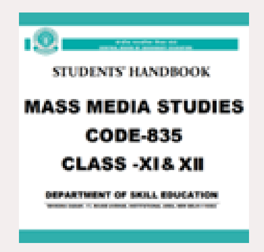
Salesmanship



Business Administration



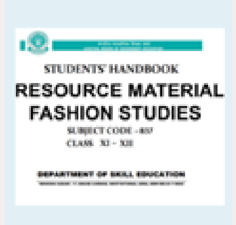
Food Nutrition & Dietetics



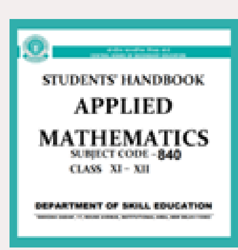
Mass Media Studies



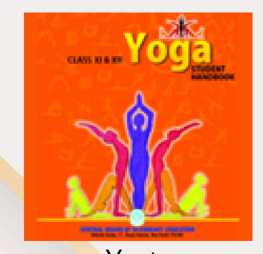
Library & Information Science



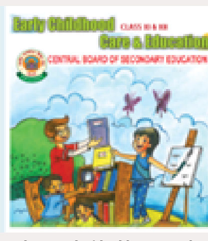
Fashion Studies



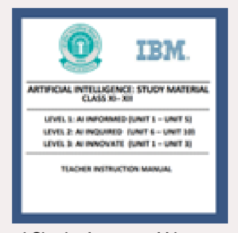
Applied Mathematics



Yoga



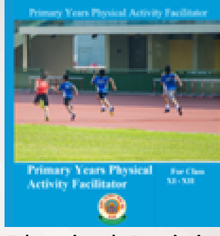
Early Childhood Care & Education



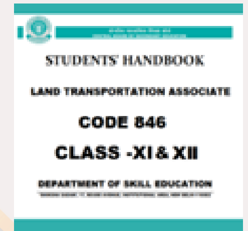
Artificial Intelligence



Data Science



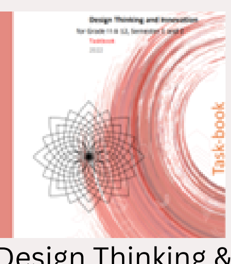
Physical Activity Trainer(new)



Land Transportation Associate (NEW)



Electronics & Hardware (NEW)



Design Thinking & Innovation (NEW)



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